

Performance Capabilities of the Data Decoder Assembly Through the Viking Era

C. R. Grauling and N. J. Jones
DSIF Digital Systems Development Section

The Data Decoder Assembly will be performing several different telemetry processing functions at various antenna type sites through the Mariner Venus-Mercury 1973, Helios, and Viking eras. These include sequential decoding block decoding and high-rate formatting of telemetry data. This article is a description of how these functions have been implemented by either test or operational software.

I. Introduction

The Data Decoder Assembly (DDA) is a recent addition to the DSIF Telemetry and Command Subsystem and is capable of performing medium rate sequential decoding, medium rate block decoding, and high-rate formatting of telemetry data with simultaneous original data record generation and transmission on the wide-band data line. (See Ref. 1 for a general description of the DDA.)

The medium rate block decoding will be performed at 26-meter-antenna sites in support of the *Mariner Venus-Mercury 1973* (MVM 73) and *Viking* Projects. The high-rate formatting function will be performed at 64-meter sites in support of MVM 73 and *Viking* missions. Sequential decoding is required by the *Pioneer 10*, *Pioneer G*, and *Helios* Projects. The hardware capability to meet these

requirements already exists in the current configuration of the DDA, although some of the required equipment has not yet been delivered to the antenna sites. A multi-mission program is currently under development and will be available for MVM 73. Preliminary analysis of the requirements and DDA hardware capabilities has been done in order to verify that project requirements can in fact be met. The results of this analysis are the subject of this article.

II. Sequential Decoding

The sequential decoding function is already implemented in the DSIF and is currently being used to support *Pioneer 10*. The decoding algorithm is implemented as a microprogram, i.e., there is an instruction in the DDA

Central Processing Unit (CPU) instruction repertoire which performs the sequential decoding algorithm on an entire frame of convolutionally encoded data.

The monitoring and control of the decoder and data handling is a software function implemented in the DDA resident software portion of the *Pioneer* Operational Program DOI-5035-OP (see Ref. 1). The sequential decoding portion of the operational program for the 1973-1975 era will differ only slightly from DOI-5035-OP. The major difference between DOI-5035-OP and the implementation of sequential decoding for the 1973-1975 era will be in the area of received data buffer management. The new program will have a slightly different data buffer allocation algorithm which will enable the DDA to handle the large frames for the *Helios* Project.

III. Block Decoding

The DDA will perform block decoding of medium rate (less than 2500 bps) block coded data. The data flow in this case is the same as in the sequential decode case, i.e., the received channel symbols are input to the DDA from the Symbol Synchronizer Assembly (SSA) coupler via a direct memory access channel. The decoding is performed by the DDA CPU. The decoded data plus time and status information are transferred to the Telemetry and Command Processor (TCP) via direct memory access through a Decoded Data Buffer which performs a data packing function in hardware.

The decoding algorithm is a hybrid firmware-software implementation. The repetitive functions of the block decoding algorithm are done via the execution of a set of special block decoding instructions. There are three special instructions used in block decoding. A typical block of received data (e.g., 32/6 comma-free, biorthogonal block coded data) is decoded using the following procedure.

Step 1. The comma-free vector is added to the received block using an EXCLUSIVE OR memory-to-memory instruction. (A received data block in this case is a set of 32 contiguous halfwords of memory, each halfword corresponding to a received channel symbol.)

Step 2. A set of 32 sums and differences by pairs is computed and stored in a temporary buffer using another special block decoding instruction. This step is repeated five times exchanging input and output pointers between executions. The final result is the set of correlations of the received data with the 32-word code dictionary.

Step 3. The correlation set is searched for the location which contains the correlation with maximum absolute value. This search operation is also implemented in firmware as a single instruction. The address of maximum correlation value provides five bits of the decoder output. The sixth bit is determined by the sign of the correlation value which is maximum in absolute value.

A test program has been written which implements this procedure. At 2500 bps, the block decoding function consumes 85% of the available processor time. The test program has the capability of comparing the decoded data with the actual transmitted data and compiling word error rate statistics. The word error rates obtained by the DDA have been observed to be the same as those obtained by the Block Decoder Assembly when both devices are decoding the same data stream.

IV. High-Rate Formatting

Wide-band formatting and transmission is done at 64-m stations which have DDAs configured with wide-band data line input/output (I/O) assemblies and magnetic tape recorders (Configuration II DDAs). This channel is referred to in Telemetry and Command Data Handling Subsystem (TCD) multi-mission terminology as the high-rate telemetry channel. A diagram of the data flow of such a DDA is found in Fig. 1.

The DDA has high-speed interfaces with the Block Decoder Assembly (BDA), the Symbol Synchronizer Assembly (SSA), and the High-Speed (HS) and Wide-Band Data Lines (WBDL). High-rate decoded or uncoded telemetry data are input through one of these channels and formatted by the DDA into 1200- or 4800-bit GCF blocks, based on configuration and standards and limits values received from the TCP. These blocks are then sent to the HS/WB unit for transmission to the Network Control System (NCS) and Mission Control and Computing Center (MCCC) via the GCF lines. The line rate used is 4800 bps for high-speed data and 28.5 kbps for wide band. An original data record (ODR) is simultaneously recorded on the 9-track magnetic tape recorders.

A detailed timing study has been done to determine the capability of the DDA to perform its function on the high-rate channel. This study used the MVM 73 maximum rates of 22.05 kbps for logging and transmission and 117.6 kbps for logging only. These rates remain the maximum required rates for all missions through the *Viking* era. Partial results of that study follow.

A. The 22.05-kbps Rate

Telemetry data input, processing, and output functions all impose timing requirements on the high-rate channel software implementation. The input constraint consists of meeting the interrupt response time of 3.27 ms imposed by the direct memory access channel on the SSA. Meeting an interrupt response time in the DDA depends on the delaying effects of the existence of higher priority external interrupts and the execution times of their interrupt processors, on the CPU time taken up by the priority interrupt firmware, and on the presence of long un interruptable assembly language instructions. The maximum time taken up by these delaying processes is 490 μ s which shows that the input restriction is satisfied.

At this rate, magnetic tape recording can be done in either background or main program routines, and does not present restrictions on the software design. The outputting of data on the Wide-Band Data Lines, however, must adhere to the timing constraints of the WB unit. This minimum interrupt response time of 860 μ s is associated with a maximum delaying process time of 290 μ s and, thus, can be met.

The processing of data is done in various background routines. Test software was written to closely resemble an operational program by simulating all anticipated external stimuli and internal responses. Using this test program the main program's executive loop was shown to contain 40%

unused CPU time which would be available for features not incorporated into the test program.

Thus, at 22.05 kbps, the DDA has been shown to perform its wide-band transmission and ODR recording functions within a 60% margin of the most severe timing constraint.

B. The 117.6-kbps Rate

The procedures for the processing of data at this rate are identical to those at the 22.05-kbps rate. However, since output is restricted to the generation of ODRs, the amount of time available for background execution is larger than at the lower rate. This will ensure the processing of input telemetry data.

Data input restrictions correspond to an interrupt response time of 418 μ s. Delaying processes, though, are a maximum of 290 μ s, since the interrupt of the SSA direct memory access channel now is of highest priority within the program. Therefore, the interrupt will be met within the time constraint specified.

Even at this highest rate, data output can be done in background routines. Based on timing calculations and the performance of a similar tape-logging program, real-time recording, including a rewrite capability, is ensured. Thus, at 117.6 kbps, the DDA performs its high-rate logging function within a 30% margin.

Reference

1. Grauling, C. R., "Data Decoder Assembly," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. IV, pp. 170-176. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1971.

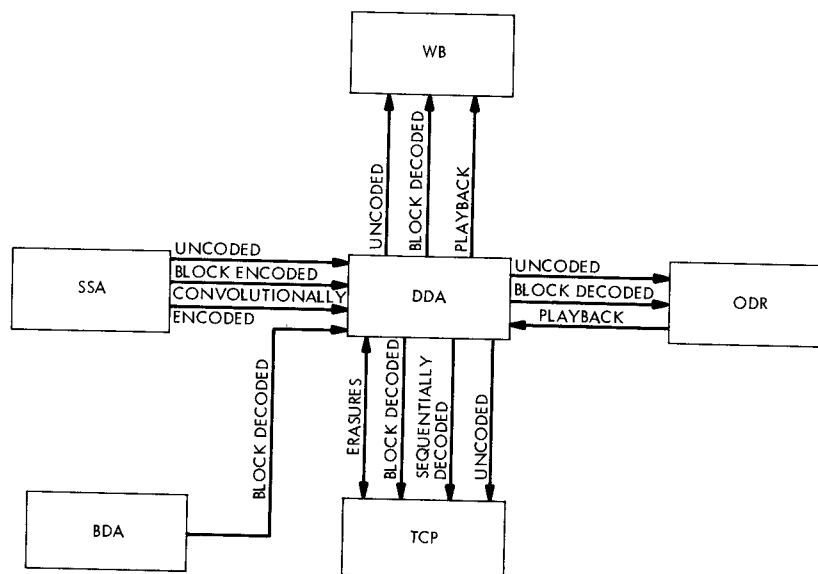


Fig. 1. Telemetry data flow at a Configuration II DDA